Introduction to Geographic Information Systems

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Lecture - 11
Different map projections

Hello, everyone today we are going to discuss different map projections. First, let us say why different map projections are required, as you know in GIS, everything has to be organized in GIS database, and you also know that maps represent three dimensional earth surfaces into 2 d. And when we convert from 3 d to 2 d for that we require some system, and that system is nothing, but map projections.

Map projection itself is a big subject, but I will try to be as brief as possible, and should not lose the sight, that we are going to use extensively in GIS map projections. Let me first bring the model here, Think that there are longitudes which are going from pole to pole, and there are latitudes and this is wired mess, only equator is shown here, if we keep a source of light inside this one, and put a photographic paper, and expose. Suppose we put here and expose, then whatever the lines which will come on the surface as a radiating line, but if we keep here, that would be little differently. If we start holding this paper, and then expose and then make it flat, then the network or grid of this latitude longitude is going to be different, and therefore, all kinds of complications then come into map projections.

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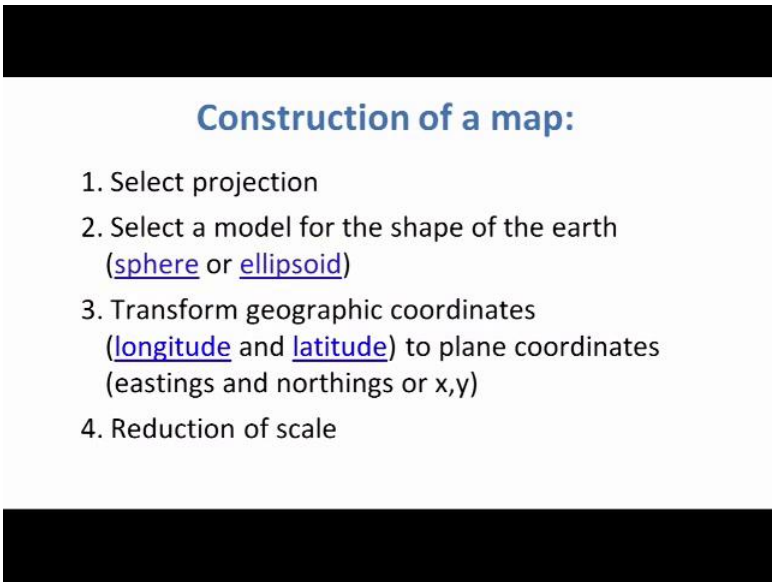

Now, another very important issue is here, that each country on the surface of the globe is located uniquely; each continent is also located uniquely. And second important thing is earth is not perfect (Refer Time: 02:32). On the poles you are having some problems, and therefore, whenever you use map projection for particular country; like say for India, that particular map projection is not going to be suitable for a country, which is at higher latitudes; say like continent like Antarctica. So, if you map projection which is being used for Antarctica, then it is not suitable for India. Another important thing here is, that each country would like to represent itself in it is true shape. So, if you change the shape, the size of the country will also change; that means the total area of the country. Now no country would ever like to have that kind of change, and therefore, there are hundreds of projections have been developed, a four different countries.

So, now there might be a question do we have universal projections? Yes, we are also having some universal projections which we will see little later, but these universal projections are though their name is universal, but may not be truly universal. So, complications whatever are there we will see. In GIS frame we have to select a projection, generally sometimes initially we keep data in geographic coordinates; that is in latitude longitude, and instead of latitude longitude, and you know degree minute's seconds, we convert them to d. This point we have discussed in previous lectures. Then we have to also select a model of the earth; that is the shape of the earth, that is sphere or ellipsoid, and then we transform these geographic coordinates latitude longitude, to plane

coordinates; that is easting northing. In all case it is not easting northing, but in certain projections we call them as easting northing, or in simple terms we can say x and y. So, these are geographic coordinates. So, all these three things are important, and for each country there are different projection are available.

The best part here is, that using a computer programs or GIS software, we can change our data, ours maps from one projection to another quite easily. It is very easy to change one projection data to another with a vector data, but it is rather little difficult comparatively, with raster data, but nonetheless the projections can be changed. Another thing is that, whenever we go to change in the scale then the again projection issues might also come there, because if you go for a smaller scale maps that, you are going to cover large area, and then curvature of earth will come, and therefore, appropriate projection has to be chosen, because the main aim here, the shape of a country should not change, because if it changes then your area of that country will also change.

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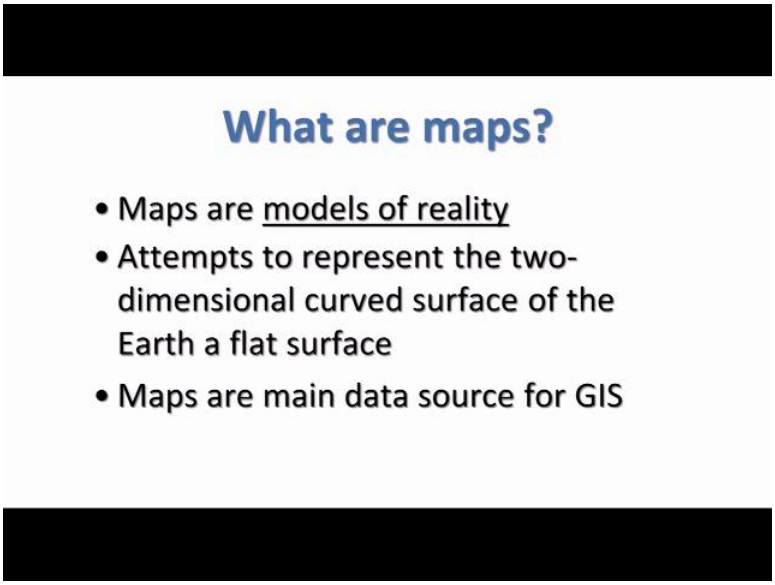

Now, you know that maps are one type of models, or models of reality which are representing the abstract form of reality, reduce reality, only selected important features are represented in a map, like topographic map. So, it is having the terrain representation through contour lines or point heights. Then it is having said hydrological information's like river network and water bodies. Then you are having road network. Then you might be having location of village's towns and other things.

So, maps are models of reality, or reduce reality, abstract reality, and we try to as mentioned that earth which is a earth as a spheroid, though it is not perfect, but this is spheroid is the 3 d body, we try to project this 3 d into 2 d, and when it is done, it has to be done through map projections and maps as we know that these are the basis of a GIS database. A basic three types of map projections are there, but then in between there are n number of variants of these basic map projections are there. Like if I use this sheet as a cylinder, I make it kind of cylinder, and put along the globe, and then glow from inside, this light of source is inside. Then whatever impression it will creates \on the sheet, photographic sheet, and then I make this sheet flat, then I will see contour lines, and these be the vertical lines, and sorry the longitude would be vertical lines, latitude would be horizontal lines.

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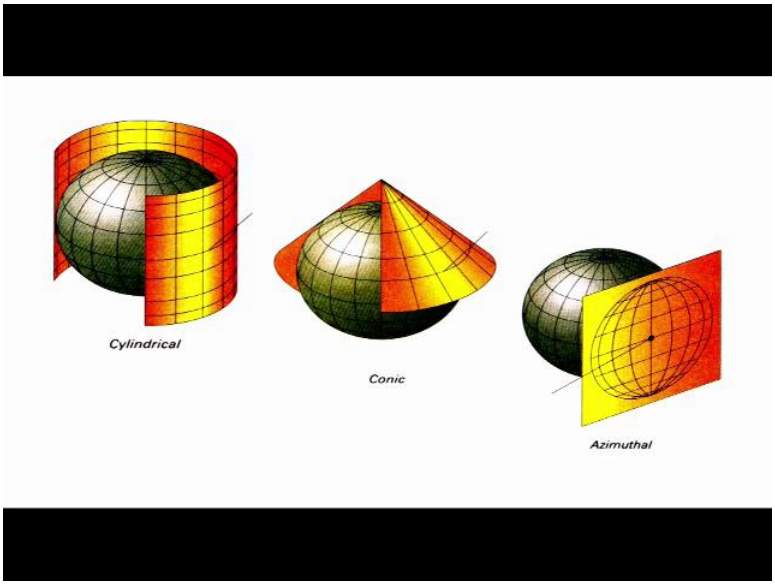

If I make that sheet as cone and then expose, then I would have in the center, the longitude would be radiating, from the poles, and then I will have circles for the latitude. Again in the Azimuthal projection, I am not going to say roll the sheet or make a cone or cylinder, instead if I keep just flat, then this is how it will be projected. So, these are the three basic types of map projection exists. Then there are variants, which we will see little later.

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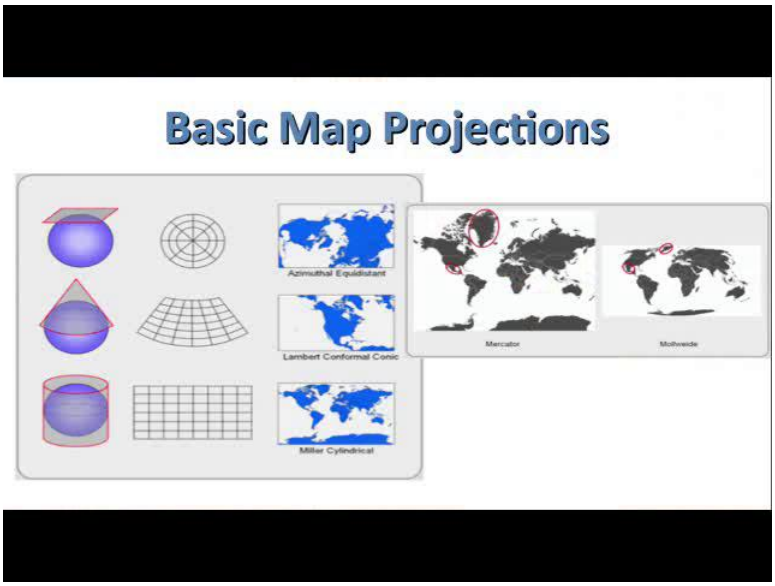

Now if I bring boundaries of the different countries or continents along with this map projection, then this is how it happens. See in case of Azimuthal projection, when sheet is not rolled or has taken the shape of the cone, this is what happens. So, you know the countries which are in the center, or a center of the sheet will have the near to representation whereas the countries at the cone nuts or margins will have different shapes and therefore, different sizes.

Similarly here as you can see the latitude would appear as a curved lines, and longitude would appear as a radiating line, in Lambert conformal conic projection, this is how it will look. So, depending on the latitude of a country location of the country in particular latitude, then the shape would take. Think in a cylindrical projection, when I use that sheet and make as cylinder, when it is make, when we flatted in a 2 d, then we get these vertical longitude and horizontal and a sort of uniform grid is there, but important point here is to note what happens to the shape of the Antarctica. You know that the shape of the Antarctica is not like this. So, in cylindrical projection it is completely distorted. The projection which I have mentioned the universal transverse Mercator projection, there too you are having this problem, that the countries which are in the middle latitudes will be have sort of true representation, but the countries at near the poles, like Antarctica or north pole, continents will have completely distortion representation.

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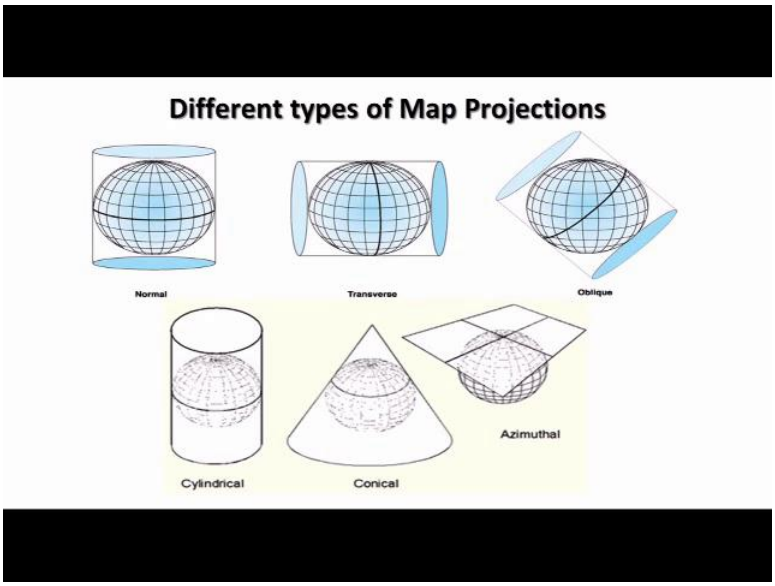

Similar thing is again shown here that depends now instead of instead of putting and fitting at the equator we can change it, these cylinders. So, in the normal position, and this is the one projection, then in the transverse position where it is not kept along with this, and then we can have oblique position. So, all kinds of variations are there, why variations are there, because each country on the globe is located uniquely. And therefore, each country would like to have it is true shape and size. And therefore, each country has developed their own projection systems.

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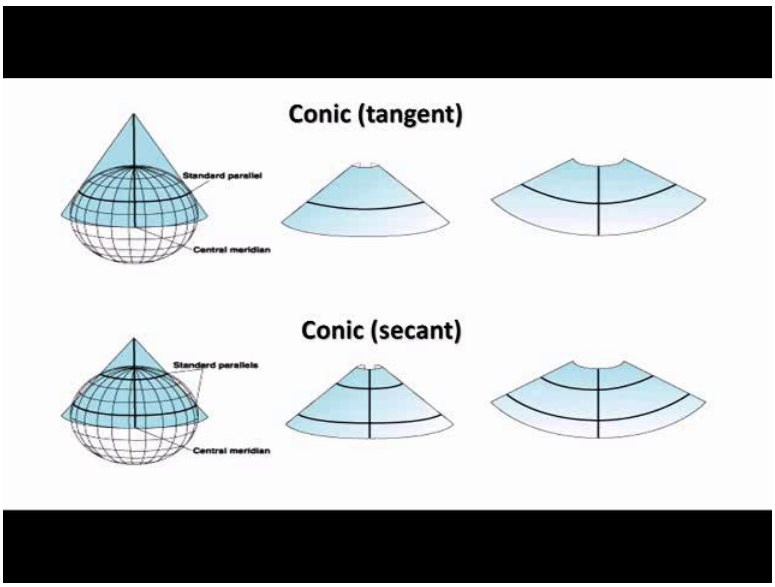

The best part I have already mentioned that, it is good that tools now a days are available to change from one projection to another.

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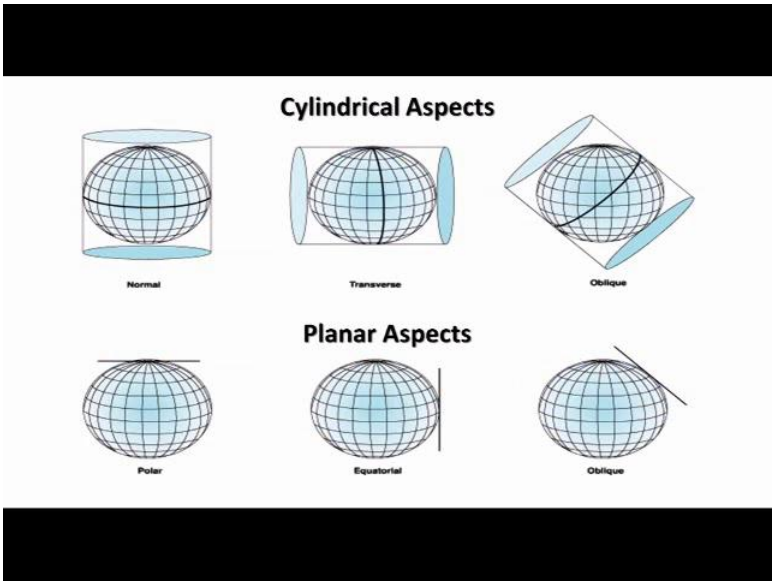

And then as mentioned that low variants are there, you can have a conic tangent, and you can have a conic secant and then this planer aspect sequence have in Azimuthal projections.

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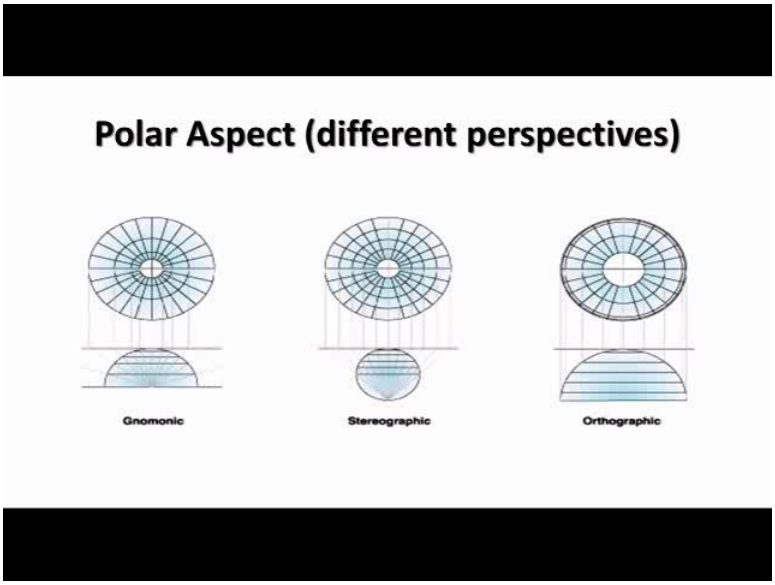

And then your stereo graphic projections are also used in geology, very common in structure geology for southern hemisphere, and also stereo graphic projections for northern hemisphere are used in mineralogy.

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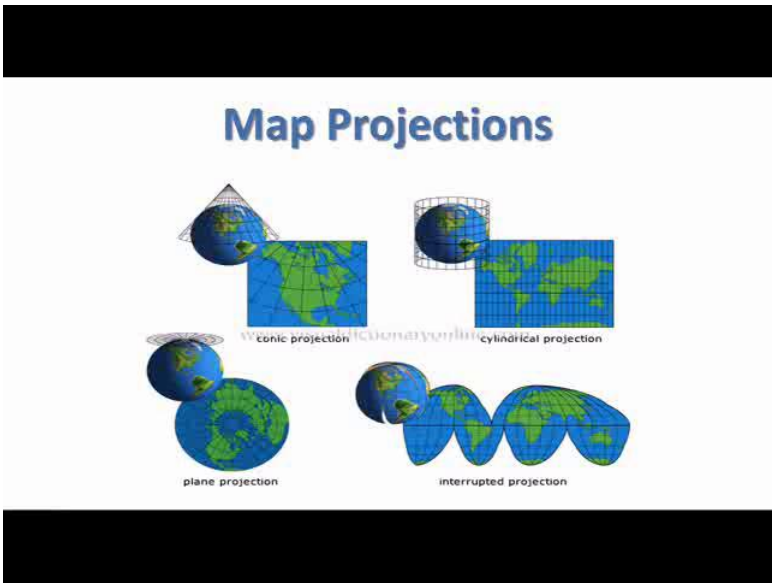

So, whole these projections are there. Again in the cylindrical projection as mentioned that the continent like Antarctica will have a big problem. Same also in the north near northern poles, but the in middle latitude regions countries will have quite nice representation. Where as in plane projection you can see that the countries at the near poles, if the sheet has been kept there, or imagine, it has been imagined then that will have true shape and size, but the countries as you go away from the center, then you are having distortion. There are projections which are like orange when you peel off, then different layer will come and that is interrupted projection. So, again here countries which are located in the middle latitude, no problem, but see what happens to the continent like Antarctica.

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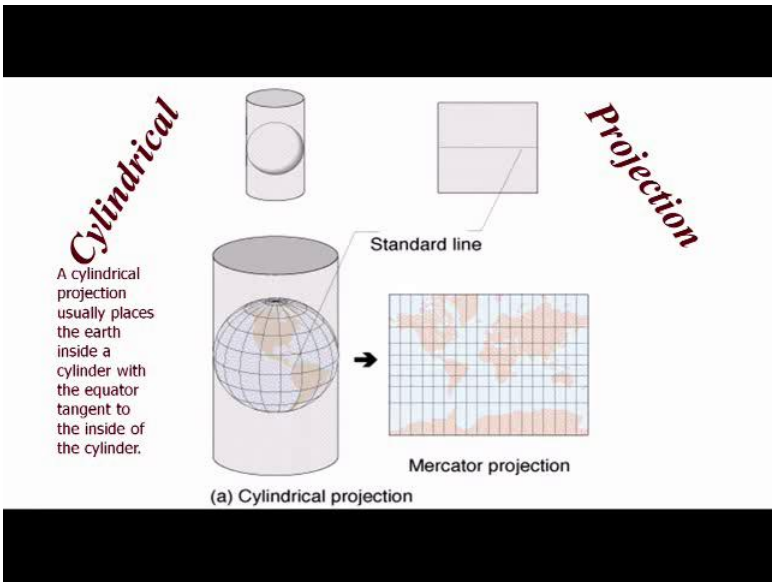

It has gone in four parts, we know that is a single land mass, and there are problems then, in cylindrical projections or universal Mercator projection, which I have taught.

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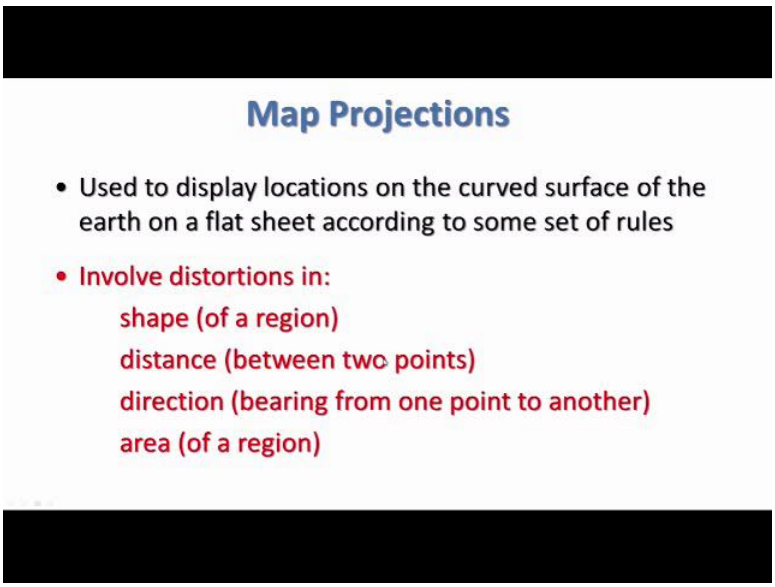

Now as mentioned earlier that a projections are used to display locations on curved surface of the earth, on a flat sheet according to some set of rules, and these rules are the shape of a region, because we want to keep intact to the shape of the country or continent. Then distance between two points are also, and then direction bearing from one point to another should not also change, and then if shape has not changed hopefully

the size of the area, of the region or the continent, or a country will also not change. So, these are things which are involved, but when you change from one projection to another, there might be lot of changes will occur in this four criteria or rules. So, basic principles are; therefore, many mapping applications the earth can be assumed to be a perfect sphere.

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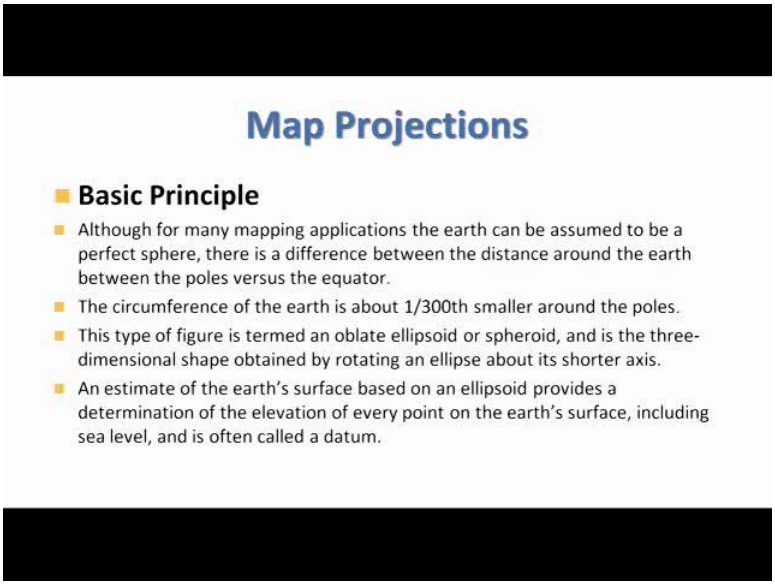

There is difference between the distances around the earth between the poles versus the equator as we know. The circumference of the earth is about one oblique three hundredth smaller around the poles, and this type of figure is termed and oblate ellipsoid or spheroid is three- dimensional shape obtained by rotating the ellipse about its shorter axis, an estimate of the Earth's surface based on an ellipsoid provides a determination of the elevation of every point on the Earth's surface, including sea level and as often called a datum.

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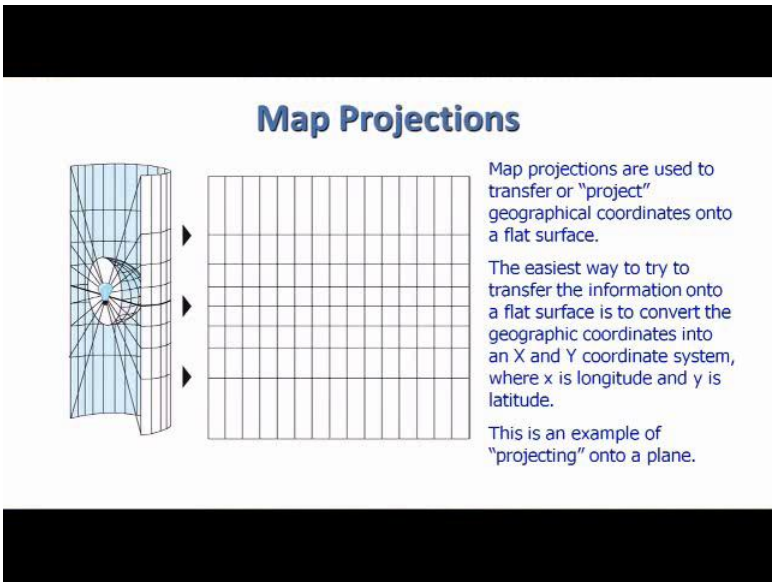

So, all these things are important here, as earlier I was mentioned that illumination source is kept in the center. A cylinder shaped paper is set here, and then you exposed, nowadays mathematically you do not have to do it physically, and mathematically using software all these things can be done. Most of the GIS good GIS softwares are capable of changing, data from one projection to another. And also if you are having basic information basic parameters available to you, you too can create your own custom design projection, to represent a particular country or land mass in it is true shape and size. So, projection is a representation of the earth 3 d into a 2 d.

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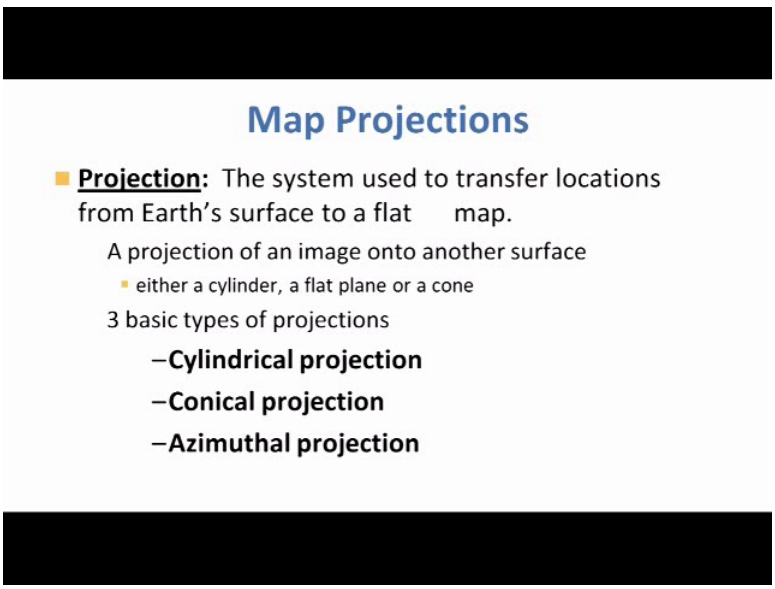

And projection of an image into another surface, either a cylinder a flat plane or cone. These are the basic types which have been we have already discussed, this one.

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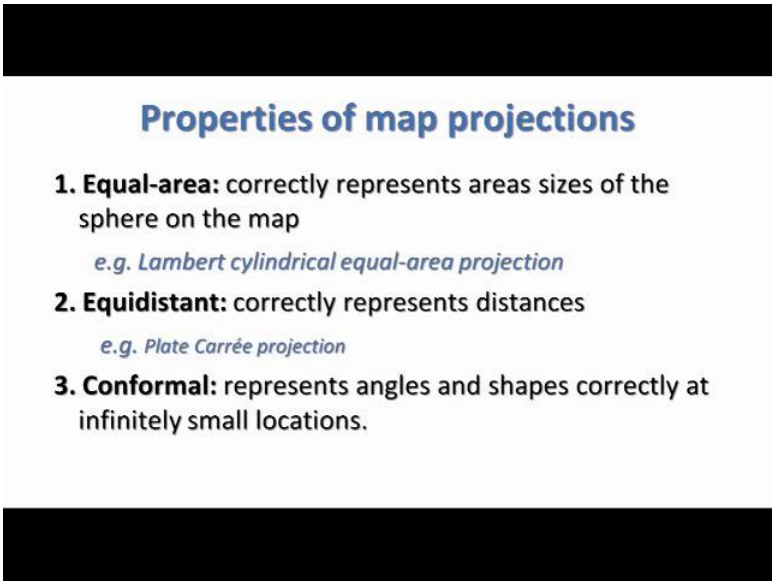

And now then what we want to keep, if you want to keep equal area, then emphasis on the area, area will be intact, but there might be other distortions will come. This is how we will go one by one, that equal area correctly represents areas sizes of the sphere on the map. A universal u t m projection, or universal transfers Mercator projection, sometimes is also called as equal area projection. So, each cell of that grid of latitude longitude represents the equal area of the earth surface. But as mentioned that on the poles, the continents or countries get distorted. In the central middle latitude region, things are more or less in order. So, that is another very popular one.

Lambert cylindrical equal area projections are there, and your universal transfer projection is also equal area projection. Then instead of equal area then you can have equidistant; that correctly represent distances between two points, and like example is, here is plate career projection or conformal projection that represents angels and shapes correctly, at infinitely small locations. So, various emphases have been given, whether you want to keep area intact, or distance intact or intact with the angle and shape. So, if the shape is also intact the country, will also most likely to have equal area, the area intact. And the example in case of conformal is the Mercator projection. Universal U T

M is mix up of equal area as well as conformal and, so that is why it is called universal Mercator transfers projection.

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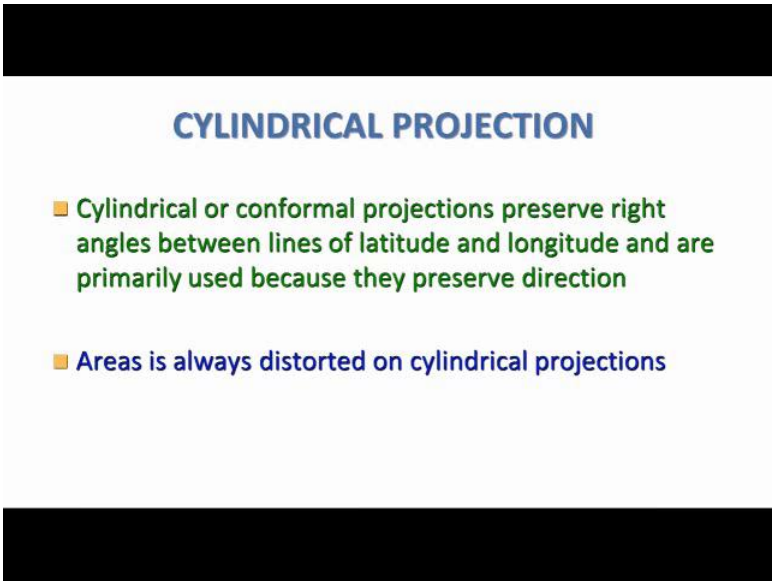

There are other issues is here, that cylindrical or conformal projections preserves right angles between lines of latitude and longitude, and are primarily used to, because they preserve direction. So, if you are having, all cells are representing as a rectangle, and your longitudes are vertical, your latitude is perfectly horizontal. Then you can have right angle preservation, and therefore, you preserve, or your direction that is say north direction east west south, all is preserved or remain intact in cylindrical projection. Area is always distorted on cylindrical projection, example is, of Antarctica.

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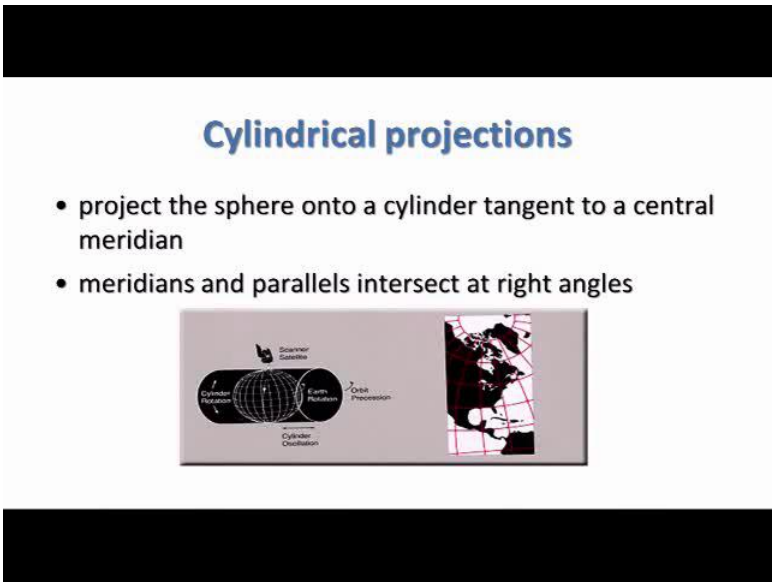

A cylindrical projection that sphere into a cylindrical tangent to a central meridian, and meridians and parallels intersect at right angles that you can see here. So, it depends on where exactly the cylinder has been assumed in this mathematical model.

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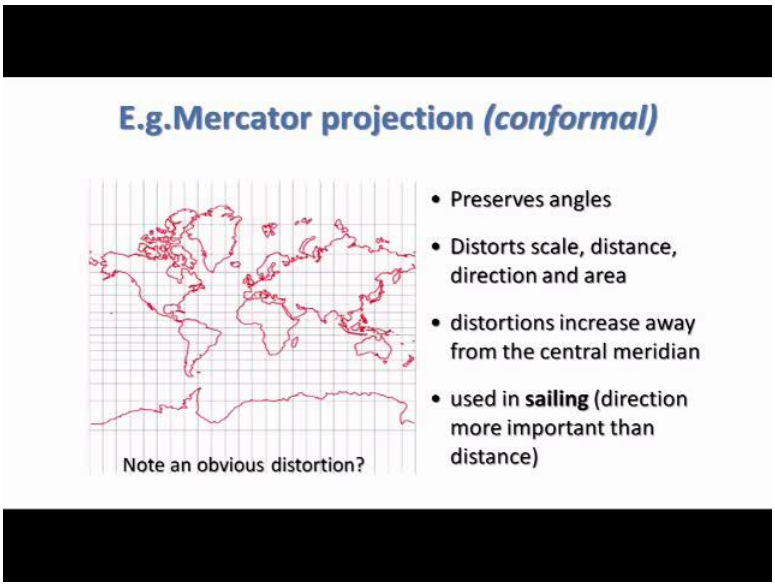

Mercator projection is also called conformal projections; this is how the distortions which are occurring to the Antarctica, but other countries are. In order to represent the true shape of Antarctica, it is better to have planer conformal or polar projections. We also call them polar projection, and when we assume when the sheet is kept at the say

southern poles, and when the light is projected through the grid, then the true shape of Antarctica will come.

So, whenever Antarctica is shown in some maps, they use the polar projection in which, in polar projection the longitude will radiate from the center of Antarctica, and latitude will have circular shape, which preserves the angles Mercator projection, distorted scales. And once a scale is distorted your distance direction and area to is distorted. So, depending on where the country is located, appropriate projection has to be chosen. Distortion increase away from the central meridian as you can realize that near poles things are would be better, and used in sailing direction more important than distance. So, may be in navigation, and water navigation or sea navigation they prefer, because they want to keep direction intact.

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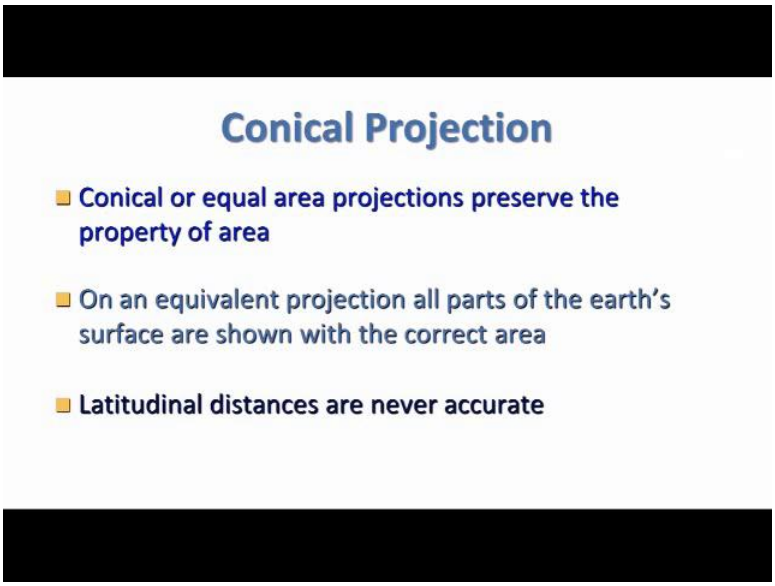

Now in conical projections also equal area projections preserve the property of area. On an equivalent projection all parts of earth surface are shown, with the correct area and latitudinal distance are never accurate. So, this is having problem with conical projections. Examples are here, that why these complications are there with conical projections.

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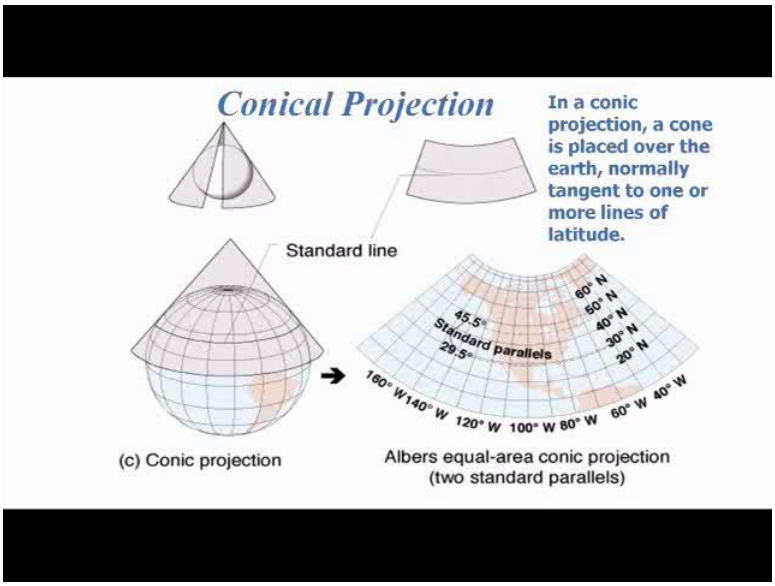

And then there are when we fix certain standard parallels, and with two parallel examples is given here, then this is called Albers equal area conical projection.

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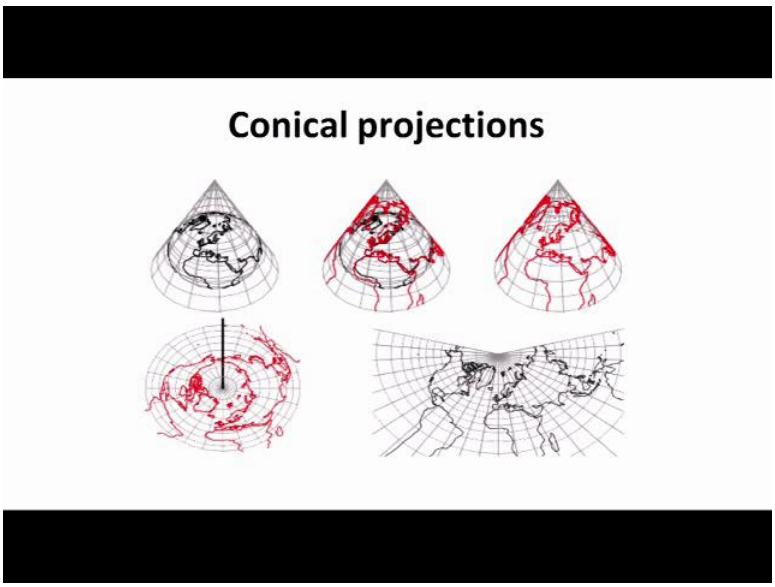

Now as I have said that it is need not to be that the cone of that paper has to be near the poles, you can make oblique projections, and depending on the again requirement, and therefore, things would be different. And this Albers equal area projection, conical projection will distorts scale, and distance except a long standard parallel.

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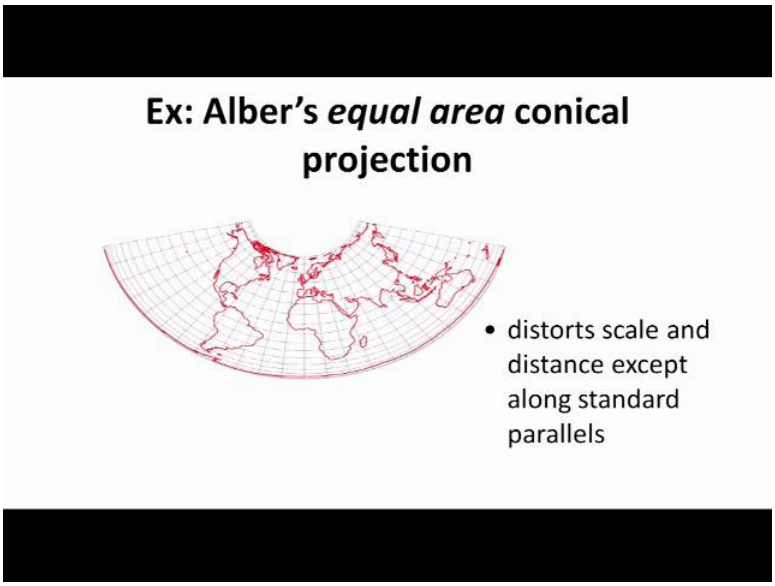

So, between roots two parallels which a user can give, as per the location of the country, between two parallels, these things can remain intact, but other things will get distorted.

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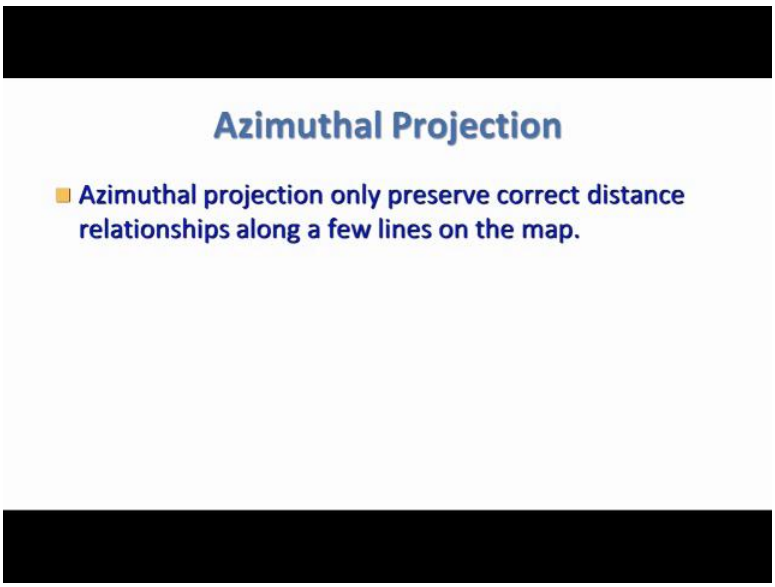

In Azimuthal projections, when you keep the sheet as flat, and wherever you want you can touch, if it is a physical model, or in mathematical model say accordingly you can assume. In Azimuthal projection only preserves correct distance, relationship along a few lines on the map.

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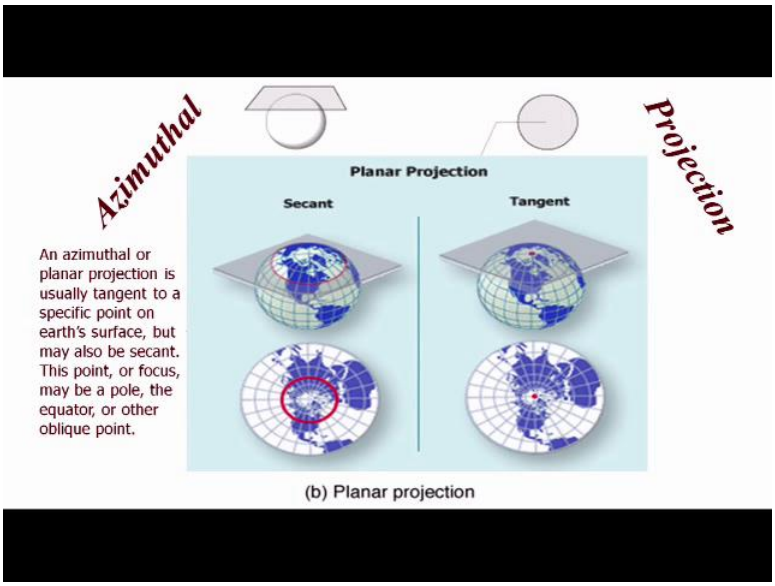

And there can be two major types in planar projection or Azimuthal projections that you can have second that we instead of assuming tangent, touching tangent at the poles, you can assume something like this as well. So, again depending where you assume, where is the country located accordingly going for true shape and size, and then very suitable for particular country, may not be suitable for other countries.

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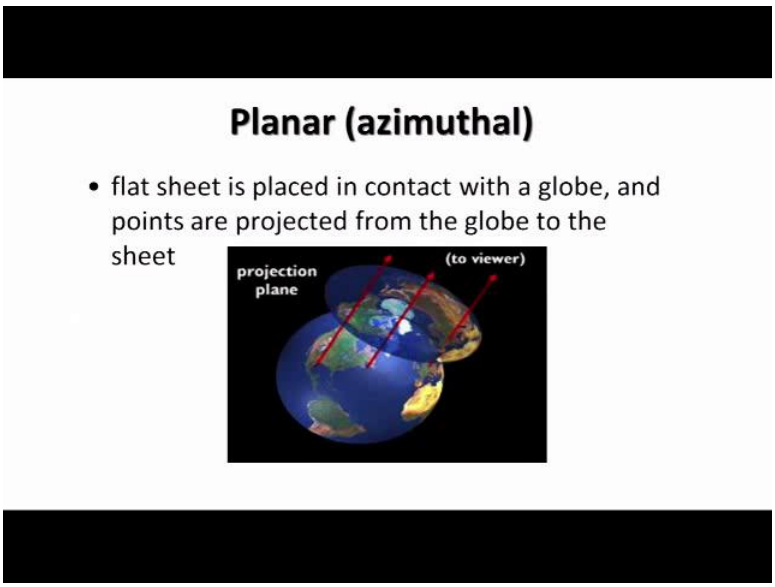

Now planar projection or Azimuthal projections, whereas I have said that we assume a flat sheet is located in contact with the globe, and points are projected from globe to the

sheet. So, then the points are projected, and then your 3 d surface may become 2 d through this projection. So, this brings to the end of this presentation. As I have already mentioned three four things ,why projections is required, because instead of a 3 d earth, we want to represent in form of maps, and therefore, you want to project map into 3 d. Now each country is located uniquely on the globe, and therefore, everyone will like to represent it is true shape and size, and when it is intended, then everyone will go for their own projection.

However, the important point which I have also mentioned, that it is good nowadays mathematical models are available. Those have been implemented into GIS. All modern GIS software supports transforming from one projection to another, transforming projection from one to another with vector data, is rather easier; however, with the raster data it is difficult.

Thank you very much.